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Proceedings of the 18th European Conference on e-Learning

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Edited by
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Understanding the Urgency and Complexities of the Energy Transition Through Serious Gaming

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Abstract: To have sustainable societies, we need to accelerate the energy transition towards clean energy solutions, however, awareness and understanding of the process is still limited, especially among young people. In addition, the topic has mainly been approached from an engineering angle, ignoring the social challenges: lack of public support for solar farms and large wind turbines could stop the need to act. An optimal balance considering the point of view from all parties involved is out of sight without a focus on social structures and a dialogue among all parties. In this context, universities have a critical role to play: these institutions build capacity through the development of new knowledge, new understanding and new insights, and can therefore provide effective solutions to complex societal challenges. In search of innovative approaches to reach young people, whose communicative paradigm has become more interactive and participatory, the use of serious gaming in formal education is gaining attention among scholars and practitioners: they can foster skills and abilities, contribute to content development of complex issues by integrating insights from different disciplines, and permit learning experiences that are not possible in real life. In this paper, we introduce "We-Energy Game", which aims to create understanding on the urgency and complexities in the provision of affordable energy from renewable sources for an entire town. During the game, players negotiate, from their respective roles, which energy source they want to employ and on which location, with the goal to make a village or city energy neutral. Then, we present findings from a pre-test and post-test completed by a hundred university students in The Netherlands to analyze the effects of the game on players awareness and understanding. Results reveal positive outcomes on awareness, as well as understanding of the complexity of energy transition and the importance (and difficulty) of collaboration among stakeholders.

Keywords: serious games, education, youth, sustainability, energy transition

1. Introduction

In respond to the complex challenges introduced by the climate emergency, the European Union have set ambitious but urgent goals: to create a transition of the energy system by improving energy efficiency and increasing the share of renewable energy in ways that would be compatible with increasing competitiveness and security of supply, and reducing greenhouse gas emissions by 80–95% by 2050, when compared to 1990 levels (EU, 2018). That means that involvement from all parties is necessary to reach those goals, from local governments to private sector and citizens; their awareness and understanding of the process is needed, however, communication and education efforts is an often-neglected pillar, especially among younger generations whose support is a significant driver in the short, medium and long term. In this context, universities have a critical role to play: these institutions build capacity through the development of new knowledge and insights and can therefore provide effective solutions to complex problems. They also produce a regular supply of highly educated, skilled people who will soon develop and implement solutions to present challenges. In words of Marie Sklodowska Curie: "nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less" (EUA, 2017).

To reach young people, traditional communicative paradigms need to be revised towards new formats that facilitate a natural interaction between the person, the interface, and the environment. In search of innovative strategies, games are gaining attention among researchers and practitioners in high education, as a tool to raise awareness and understanding on sustainability and energy transition. Games that are intended to fulfil a purpose, convey ideas and values, and sometimes, to influence the players' thoughts and actions in real life have received the name of "serious" games (Frasca, 2007). When used in formal education, these games can foster awareness, skills and abilities, contribute to content development, and allow experiential learning.

In this paper we introduce "We-Energy Game" as a case study: a serious game which aims to create awareness and understanding on the urgency and complexities in the provision of affordable energy from renewable sources for an entire town. The game has been used among international students in higher education

institutions in The Netherlands. In this paper we also present findings from a pre-test and post-test to analyze the effects of the game on players.

2. Games and education

While youth shows a growing interest for video games, educators are observing a declining motivation for school (Kemp, 2006). Scholars have found out that games appear to have high intrinsic motivation assets, and this has been the basis for research conducted in the field of (video) games and education. One of the earliest works in intrinsic motivation was carried out by Malone and Lepper (1987); they studied what makes computer games interesting and exciting, establishing a taxonomy of intrinsic motivation.

In the last years, the interest in studying the potential of games beyond their motivational value for learning has produced an increasing number of papers and conferences proceedings (Turkay et al., 2014). According to Squire (2006), one of the emerging ideas is to think of games as "designed experiences in which participants learn through a grammar of doing and being". In the same line, Gee (2004) talks of games as enablers of "situated language and learning", an idea related to theories in situated cognition, which suggests that learning is tied to the authentic activity, context, and culture within which knowledge is developed.

The field of game-based learning and serious games in the education sector have also seen an increasing number of studies related to effectiveness, advancing knowledge of the challenges and possibilities of creating, evaluating, and implementing games in the education sector. Most studies have found positive changes in awareness (Van Pelt, 2015). Soekarjo and van Oostendorp (2015) have also found increased knowledge of players in five of the sixty games reviewed after playing them. However, less evidence is available on changes in attitudes and behaviours. According to a research conducted by Zhonggen (2019), one of the main reasons for the effectiveness of serious games in education may be related with the impact of these games on learners' mood: effective serious games try to create a positive mood in order to encourage players' interest in gameplay, as well as better academic performances.

However, in practice many education practitioners feel confused and lack guidance on how to evaluate quality of serious games that available for free online and on how to implement these games in class. When games are considered for instructional use, many factors must be weighed (Turkay et al., 2014). To bridge this gap, Ouariachi et al. (2019) developed an evaluation tool that presents a definition of quality and a scale of scores for each of the criteria, divided into five different categories (identification, narrative, contents, gameplay, and didactics), then the integration of the five dimensions provides quality scores that allow to determine the quality scenario of games (low quality, medium quality, and high quality). This tool can be used by teachers when deciding if certain serious games fit their needs to be implemented in class.

3. Energy-related serious games

Sustainability or energy literacy can play an important role in promoting political decisions and changes at the individual and collective levels; however, it is not easy or "attractive" to engage the public, especially young people, in these complex issues. Serious games make use of entertainment for educational purposes, facilitating the process in which players cultivate their knowledge and practice their skills in a subconscious way. Today, serious games are one of the growing areas in educational media; its market is expected to grow from 3.2 billion U.S. dollars in 2017, to 8.1 billion in 2022 (Statista, 2018).

Most of studies that map and explore serious games in the field of climate change or sustainability have found that mitigation is the main topic, understood by United Nations as efforts to reduce or prevent emission of greenhouse gases (Katsaliaki & Mustafee, 2014; Ouariachi et al., 2017). Mitigation can be understood as using new technologies and renewable energies, making older equipment more energy efficient, or changing management practices or consumer behaviour; it can be as complex as a planning a new city or as a simple as improvements to a cook stove design. Concretely, serious games on energy issues have grown and diversified exponentially over the last years but, especially, these types of games have experienced most progress in an online format.

Different web platforms are available to the public and for free that serve as a repository of these types of games, such as Games4Sustainability or Gamepedia, targeting academics, trainers, NGOs, teachers, students, and anyone interested in this topic. Examples of energy related serious games include "Enercities", a game in

which the player is faced with the challenge of developing an eco-friendly city dealing with issues such as pollution, energy shortages, and renewable energy. Players place buildings on a grid to grow their city. They need to balance energy sources, cash flow, and the city's economy, wellbeing, and environment. Another example is WindMill Game, a strategy game about building wind farms to create clean energy profitably. Players fulfil a specified energy offset goal as quickly as possible by building turbines smartly, and research locations carefully for the best wind conditions, avoiding upsetting the local citizens by building turbines in undesirable places.

4. Case study: We-Energy Game

The We Energy Game (developed at EnTranCe the Center of Expertise Energy in Hanze University of Applied Sciences in Groningen, The Netherlands, under the project "From A to Sustainability") is a serious game aiming to create awareness and understanding on the urgency and the challenges in the provision of affordable energy from renewable sources for an entire town or city. The game can be played on board or on screen by a minimum of five players who take the roles of:

- Production: a project leader who needs to produce a certain amount of energy
- People: the citizens of the area where the game is played
- Planet: how green/clean is the energy production
- Profit: how much profit is made by the different projects
- Balance: how easy to work with is the energy source for the network-operator

The exact calculations and effects of the different options are based upon scientific research and the latest insights. While playing, players negotiate from their respective roles which energy source they want to employ and on which location. Once agreement is reached, they place the icon that represents that energy source on the map and they check the consequences for each of the roles (production, people, planet, profit and balance). Through playing the game, they will realize that without collaborating with the others, they will not be able to achieve their ultimate goal of creating a sustainable energy mix for their town or city. In the process, players also realize that there are many available solutions to reach an optimal balance, and that sustainability is not just a technical issue, but a social one as well. For example, even though there is great support for solar panels, the sun does not always shine, so other resources are needed; wind provides a lot of energy, but can also encounter protest by local residents; biomass could be a good solution, but its yields are less and its environmental footprint is greater.

Figure 1: One of the location representations of We-Energy Game

The image above (Figure 1) is an example of locations represented in We-Energy Game, using real data based on own research and an open street map. In the Netherlands, population ranges from 500–5000 inhabitants in a village to 10,000–50,000 inhabitants in a populated area, like a city. The game uses four levels of difficulty by making use of four different maps in The Netherlands, allowing players to experience the challenges of making different towns with different populations sizes and urban structures energy neutral: Diever (goal: 25 points),

Meppel (50 points), Assen (75 points), Emmen (100 points). The goal of the gameplay is that players realize that the larger the locations are, the more challenging to achieve common goals and keep all characters satisfied. The scores are also based on realistic effects of each variable and refer to the amount of energy, emissions, and impact. The game finishes when all roles reach the total score for the selected town, maintaining a positive balance.

4.1 Implementation of the game in class

The We-Energy Game has been played by a variety of groups, such as energy cooperative members, business, municipality representatives, but also students. The game is suitable to be implemented in class for several reasons: on the one hand, it covers a variety of key competences and abilities. They can be integrated into XXI century skills—learning and innovation skills (critical thinking and problem solving), digital literacy skills, and career and life skills (adaptability, social interaction, accountability). On the other hand, the game is characterized to be interdisciplinary, which means that it can be used simultaneously for different disciplines, such as social studies or environmental studies, and to allow group work in class.

The game has been implemented with students in higher education institutions, such as Hanze University of Applied Sciences. Students were Dutch and international and they belong to different disciplines: marketing, international communication, engineering, etc. The game session is facilitated by an expert on energy transition together with a teacher from the respective class. Before starting, students are introduced to the game goals and rules, then they are split into groups of five. The length of the gameplay is about 30 minutes when playing two different maps, and therefore two different levels. As mentioned earlier, the educational objective is to raise the complexity once they are familiar with game mechanics in order to understand that the larger the locations are, the more challenging to achieve common goals and keep all roles satisfied. After playing the game, there is a debriefing session where information is shared and examined.

4.2 Analysis of the effects

4.2.1 Methodology

In search of evaluating the effects of the game on students' level of awareness and knowledge, we conducted a pilot study using a pretest-posttest design research. Participants' awareness and understanding are assessed by using a survey before playing the game and after playing the game, including as main questions (Table 1): how aware and informed do they feel about the energy transition, how much do they agree that there are many available solutions to reach an optimal sustainable energy mix for an entire town, and how much do they believe energy transition is a social, economic or technical issue. Respondents are asked to rate those statements on a four-point Likert scale ranging from respectively 'not at all' to 'a lot'. They are also asked in an open question what their main learning points are.

Table 1: Operationalization

Variable	Indicator	Measurement
Awareness	Perception on own information level	Four-point Likert scale
Knowledge	Availability of solutions	Four-point Likert scale
	Factors of energy transition	Four-point Likert scale
	New learning aspects	Open question

The researchers used Google Forms to compose and send the surveys online. We translated the students´ names into numbers to guarantee their anonymity. We also conducted a group discussion with a smaller group of students to understand their opinion about the game and to get more qualitative data about their interaction with the game. The discussion, facilitated by researchers just after playing the game, was aimed to be a collective exchange of ideas to share their opinions about the game and their main take-away. The sample of this study is composed by 100 bachelor (Dutch and international: German, Lithuanian, Czech, Azerbaijani, Bulgarian, British, Mexica, Chinese, Turkish, Ukrainian) students aged between 18 and 25 years old (67,6% female; 32,4% male), at Hanze University of Applied Sciences.

4.2.2 Findings

From the survey, results reveal an increase in awareness about the energy transition. Before playing, majority of students feel "not so much" aware and informed about energy transition, while after playing, majority of

students feel "quite a lot" aware and informed about the topic. In total, before playing there are only 22,9% students feeling aware (quite a lot + a lot), and after playing there are 74,8% students. Therefore, there is an increase of 51,9% students feeling more aware after playing the game.

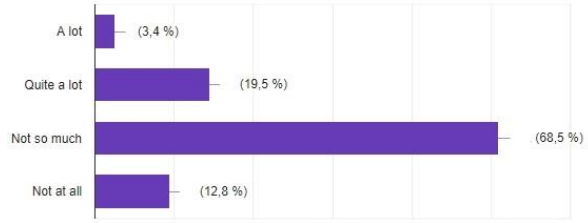

Figure 2: Pretest

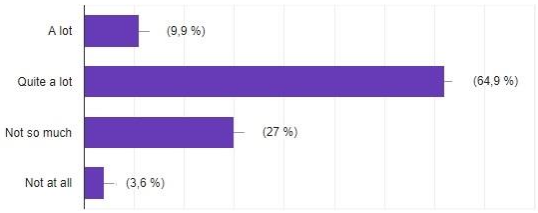

Figure 3: Posttest

When asked how much do they agree that there are many available solutions to reach an optimal sustainable energy mix for an entire town, there is an increase of 18,7% students who believe (quite a lot + a lot) that there are many available solutions comparing pretest and posttest. Lastly, to the question how much do they believe energy transition is a social, economic or technical issue, all three categories experience an increase after playing the game. In the open question, students acknowledge to understand the complexities of the energy transition but also the importance of collaboration and dialogue among different stakeholders to find solutions.

From the group discussion, findings reveal that students perceive the game as fun and that they prefer to have this type of interactive practice rather than a traditional class characterized by a unidirectional transmission of information. The discussion also shows how educational games have still a long way to go to achieve the high levels of engagement of commercial games which present better graphics, more challenges and different types of interactive mechanics.

5. Conclusions

Using We-Energy Game as a case study, this paper offers insights into the opportunities of using serious games in formal education, concretely in higher education institutions. It has contributed to raising awareness and understanding on the urgency and complexities of energy transition in an interactive, innovative and attractive way for young people. In accordance with other studies, serious games have potential in raising awareness and knowledge on complex issues -enhancing cognitive abilities, affect, and pleasant mood-, however, it remains to be seen to what extent these types of tools have also an impact on attitudes and behaviours.

In order to explore the impact of serious games on learning, different implications must be taken into account for educators and facilitators. From our experience, feedback, interaction among players, and debriefing. Zhonggen (2019), for instance, coincides in these three factors and adds backstory-production, realism, artificial intelligence-adaptivity in order to achieve success in learning. Other authors include the perceived usefulness of the game, ease of use, and goal clarity as indicators of satisfaction and effectiveness in use of serious games: when learners clearly predict the goals and ease of use, they tend to focus on the contents and enjoy themselves (Wang et al., 2017).

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